Lab: Exploring the Properties of Acids and Bases

FOR THE TEACHER

Summary
In this lab, students will rotate through five stations. They will explore the properties of many household substances and discover a few properties of acids and bases.

Grade Level
High School

Objectives
By the end of this lab, students should be able to
- Differentiate between acids and bases.
- Identify properties of acids and bases.
- Identify household as acidic or basic based on their properties.

Chemistry Topics
This lab supports students’ understanding of
- Acids and bases
- pH scale
- Indicators

Time
Teacher Preparation: 45 minutes
Lesson: 90 minutes

Materials
Station 1
- Red and blue litmus paper strips (1 per student)
- Full Dixie cup of vinegar (or lemon juice)
- Full Dixie cup of saturated baking soda solution
- Cotton swabs (1 per student)

Station 2
- Goldenrod paper
- 50 mL of vinegar in a Dixie cup
- Spray bottle filled with indicator (boiled red cabbage)
- ~ 20mL of whole milk/class
- 150 mL beaker of tap water
- 150mL beaker of vinegar (or lemon juice)
- 250 mL beaker labeled “A”
- 250 mL beaker labeled “B”
- 2 stirring rods
- 10 mL graduated cylinder
- 2 pipettes

Station 3
- Pipettes (1 for each sample and 1 for the indicator)
- 500 mL beaker of indicator solution (boiled red cabbage juice)
- 9 - 10mL Graduated cylinders (labeled 1-9.)
- 9 - 150 mL labeled beakers of the following solutions/class
  - HCl
  - Acetic acid
  - Water
  - Sodium bicarbonate
  - NaOH (or lye)
  - Borax (or other detergent)
  - Milk of Magnesia (or other antacid)
  - Egg whites
  - Soda (coke, sprite, diet coke)
- Alternatives (mouthwash, OJ, shampoo, lemon juice, glass cleaner with ammonia, bleach, tomato juice, salt water, Drano)

Station 4
- 2 - small empty beakers labeled HCl and NaOH
- ~10 mL of 1M HCl in a labeled beaker/class
- Red or blue litmus paper (3/group)
- ~20 mL of phenolphthalein in a beaker/class
- Pipettes
- ~10 mL 1M NaOH in labeled beaker/class

Station 5
- 150 mL beaker labeled tap water
- 150 mL beaker labeled distilled water
- 5 Small samples or solutions labeled A-E in beakers of any of the following substances:
  - Soda (coke, sprite, diet coke)
  - Acetic acid
  - Lemon juice
  - Sodium bicarbonate
  - NaOH (or lye)
  - Borax (or other detergent)
  - Milk of Magnesia (or other antacid)
  - Egg whites
- Alternatives: mouthwash, OJ, shampoo, lemon juice, glass cleaner with ammonia, bleach, tomato juice, salt water, Drano)
- 1 - 2 conductivity meters
- Well plate
- Pipettes
- Stirring rod(s)
- Magnesium ribbon cut into small pieces

Safety
- Always wear safety goggles when handling chemicals in the lab.
- Students should wash their hands thoroughly before leaving the lab.
- When students complete the lab, instruct them how to clean up their materials and dispose of any chemicals.
- When working with acids, if any solution gets on students’ skin, they should immediately alert you and thoroughly flush their skin with water.
- Do not consume lab solutions, even if they’re otherwise edible products.
- Food in the lab should be considered a chemical not for consumption.

Teacher Notes
- I performed this lab in one day (90 minute block) with pre AP students. Academic classes performed this lab in two days.
I projected a countdown timer in order to ensure students remained on task and completed the stations in the allotted time. I printed out six copies of the lab station instructions for each station and left those on the corresponding lab tables. I only provided students copies of the data tables and questions. It is vital that every beaker is labeled appropriately.

- Preparation of red cabbage indicator (done by the teacher the night before)
  - Cut ½ of a cabbage into small pieces.
  - Cook cabbage in 2 liters of water for about 15 minutes
  - Separate the bluish-purple liquid from the cabbage and let it cool

- Tongue images for Station A: Image sources:
  - Source 1
  - Source 2

**FOR THE STUDENT**

**Lesson**

**Exploring the Properties of Acids and Bases**

**Background**
Acids and bases are not only present in the chemistry lab. Acids and bases encompass our lives. Today, we will test the properties of many household substances you have encountered already.

**Pre-lab Questions**
Predict whether you think the following substances are an acid or a base.

a. Vinegar
b. Water
c. HCl
d. NaOH
e. Aspirin
f. Tums (or Pepto Bismol)
g. Baking soda
h. Egg whites

**Objective**
You will test properties of acids and bases in order to write a conclusion regarding the properties of acids and bases. How can the properties of household products determine if they are an acid or a base?

**Materials**
These materials will already be at each of your lab stations.
- Red and blue litmus paper strips
- Goldenrod paper
- Stirring rods
- 10 mL graduated cylinders
- Pipettes
- 150 mL beakers, labeled with solutions
- Red cabbage indicator
- Phenolphthalein
- Conductivity meters
- Well plate
- Magnesium ribbon cut into small pieces
- HCl
- Acetic acid
- Water
- Sodium bicarbonate
- NaOH (or lye)
- Borax (or other detergent)
- Milk of Magnesia (or other antacid)
- Egg whites
- Soda (coke, sprite, diet coke)

**Safety**
- Always wear safety goggles when handling chemicals in the lab.
- Wash your hands thoroughly before leaving the lab.
- Follow the teacher’s instructions for clean-up of materials and disposal of any chemicals.
- When working with acids and bases, if any solution gets on your skin immediately rinse the area with water.
- Do not consume lab solutions, even if they’re otherwise edible products.
- Food in the lab should be considered a chemical not for consumption.

**Procedure**

**Station 1**

*Activity 1, Part A: Are you acidic, neutral, or basic?*
1. Take one piece of red litmus paper and a piece of blue litmus paper. Place about one inch of the paper in your mouth.
2. Wait 5 seconds, then take out the paper and see if either changed color. In your data table, record your observations. You will determine whether your saliva is acidic or basic. (red to blue means basic; blue to red means acidic, no change mean neutral)
3. Throw your used litmus papers in the trash.

*Activity 1, Part B: Tasting acids & bases*
1. Dip a cotton swab in cup labeled vinegar & place it on different parts of your tongue. In your data table, record where you taste the acidity.
2. Dip the other side of the cotton swab in cup labeled baking soda and place on different part of your tongue. In your data table, record where you taste the bitterness.
3. Throw your used cotton swabs in the trash.
   The areas of the tongue sensitive to tastes:
Station 2
Activity 2, Part A: Secret Message
1. Dip a cotton swab into the Dixie cup of vinegar & use it to write your secret message on the paper.
2. Allow about 1-2 min for the message to dry completely. Start on part B while it is drying.
3. Read the “invisible ink” message by misting it lightly with the spray bottle filled with red cabbage juice.
4. Record your data. You may discard or keep your secret message.

Activity 2, Part B: Denaturation of milk
1. Add 2 mL of milk into each beaker labeled A & B.
2. Record initial color in your data table.
3. In beaker A, add 6 drops of water. After each drop, mix with stirring rod. Record any changes in your data table.
4. In beaker B, add 6 drops of vinegar. After each drop, mix with stirring rod. Record any changes in your data table.
5. Rinse the A & B beakers, graduated cylinder, and stirring rods.

Station 3
1. Choose 9 substances you would like to test. Obtain approximately 5 mL of each substance in the numbered graduated cylinders. Keep track of where you put each solution by recording it in the data table below.
2. In your data table, predict each substance as basic, neutral, or acidic.
3. In your data table, record the initial color of each substance to be tested.
4. In your data table, record the initial color the red cabbage indicator.
5. Using the pipette, add 5-7 drops of indicator to each beaker (up to 5 mL=80 drops) swirling the beaker after each drop. Once you have a color change that remains in solution, you may cease adding indicator. Some may NOT change, as they are neutral substances. Record your observations in the data table.
6. Organize all beakers from most acidic to most basic using as a guide for the pH scale for red cabbage juice
   *most acidic pink → red → purple → blue → green → yellow most basic*
7. Estimate the pH value of each substance by using the pH scale you created with the beakers and record in the data table.
8. In your data table, classify each product as acid, base, or neutral. Rinse all glassware used.
Station 4

1. Using a pipette, place 5 drops of HCl into a clean beaker.
2. Use one piece of litmus paper to test the pH of the HCl. (Red to Blue means basic; blue to Red means acidic, no change mean neutral)
3. Record the color and determine if this is an acid or base in your data table.
4. Using a pipette, add 1 drop of phenolphthalein to the beaker. The solution will remain colorless.
5. Add sodium hydroxide, drop by drop, gently swirling the beaker gently until you see the first pale pink color that does NOT go away with shaking.
6. Using the litmus paper, record the color of the litmus paper as you did in step 3.
7. Using a different pipette, add 5 more drops of NaOH. Record the color and determine if this is an acid or base in your data table.
8. Rinse the test tube thoroughly in the sink and discard the used pH paper away in the trashcan.

Station 5

How do Acids and Bases feel?

1. Dip the tip of your finger into the beaker of water to wet it. Rub your thumb and wet finger together. It should not feel oily or slippery, as water is a neutral substance.
2. Re-wet your finger and use that finger to pick up a small amount of each powder or liquid out of its beaker and repeat the feel test. In your data table, describe each substance as either sticky or slippery. Use a paper towel to wipe your fingers.
3. Use the scoopula or pipette to take out a small portion of each substance and place each into the well plate. Ensure you know the order you placed the substances in the well plate.
4. If the material is a powder, you will need to create a solution. Using the pipette, add 2-5 drops of water to each beaker and use a stirring rod to dissolve the substances. Make sure you rinse the stirring rod in between each sample.
5. Do acids and bases conduct electricity? Using the conductivity meter, test the conductivity of each substance. DO NOT submerge the battery parts of the conductivity meters, only the end of the metal nodes needs to touch the solution in order to produce results. Do not forget to clean the nodes of the meter between use by dipping in distilled water and wiping with a paper towel.
6. How do Acids and Bases React with Metals? Carefully place ONE small piece of magnesium into each solution on your spot plate. Use a stirring rod to submerge the magnesium. Look for bubbling as a positive test, or no bubbles. Record your observations.
7. Magnesium pieces may be wrapped up in a paper towel and thrown away. Rinse the spot plate, scoopula, and dry them off. WASH YOUR HANDS THOROUGHLY!

Observations

Activity 1

Part A

<table>
<thead>
<tr>
<th>Color of Litmus paper before placing on tongue</th>
<th>Color of litmus paper after placing on tongue</th>
<th>Acidic, neutral, or basic?</th>
</tr>
</thead>
</table>

American Association of Chemistry Teachers
### Part B

<table>
<thead>
<tr>
<th>Location of where you taste acidity</th>
<th>Vinegar</th>
<th>Baking soda</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location of where you taste bitterness</td>
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<td></td>
</tr>
<tr>
<td>Taste</td>
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<tr>
<td>(sour or bitter)</td>
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<tr>
<td>Acid or Base?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Station 2

#### Part A

<table>
<thead>
<tr>
<th>Color of message before cabbage juice</th>
<th>Color of message after cabbage juice</th>
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<tbody>
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#### Part B

<table>
<thead>
<tr>
<th>Beaker</th>
<th>Observations A</th>
<th>Observations B</th>
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</thead>
<tbody>
<tr>
<td>Milk</td>
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<tr>
<td>Milk with water</td>
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<tr>
<td>Milk with vinegar</td>
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</tbody>
</table>
### Station 3

<table>
<thead>
<tr>
<th>Sample Name</th>
<th>Prediction (Acid, Base, Neutral)</th>
<th>Initial color of solution</th>
<th>Initial color of indicator</th>
<th>Final color of solution</th>
<th>Estimated pH Values</th>
<th>Acid</th>
<th>Base</th>
<th>Neutral</th>
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</thead>
<tbody>
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<td>9.</td>
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</tbody>
</table>

### Station 4

<table>
<thead>
<tr>
<th>Sample</th>
<th>Color of litmus paper (red, blue, or no change)</th>
<th>Acid, base, or neutral?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 2. HCl</td>
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<tr>
<td>Step 5. Pale pink solution</td>
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<td></td>
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<tr>
<td>Step 6. 3 more drops of NaOH</td>
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</tbody>
</table>

### Station 5

<table>
<thead>
<tr>
<th>Substance</th>
<th>Feel (sticky or slippery)</th>
<th>Conductor Y or N</th>
<th>Reaction with Mg (bubble or no bubbles)</th>
<th>Acid, base, or neutral?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
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Analysis

1. Why was it important that we test water even though we know water to be neutral?

2. Many times ingested food produces excess acid in the stomach, causing pain. The pain is stopped by taking anti-acids over-the-counter medications such as Pepto-Bismol or milk-of-magnesia. How do these work?

3. List three properties of acids you discovered based on your results.

4. List three properties of bases you discovered based on your results.

5. Are most house cleaning substances acids or bases? Provide reasoning behind your conclusion.

6. Are most food product acids or bases? Provide reasoning behind your conclusion.

7. What are indicators?

8. List some of the substances you tested in activity 3 from most acidic to most basic.